Final Report

3M Brookings Ethylene Oxide Abator I Efficiency

LIMS Project Number: E19-0693

Testing Laboratory
3M EHS Laboratory

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The laboratory's quality system has been audited and was found to be in conformance with the EPA GLPs (40 CFR 792) as well as ISO/IEC 17025:2017 by an independent assessment. The specific test included in this report is not on the lab's scope of accreditation.

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3M EHS Laboratory – Abator Efficiency
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Date of Report: Date of Last Signature

1 Introduction/Summary

Ethylene Oxide Abator I at 3M Brookings was tested for destruction efficiency during an engineering test on 11/12/2019. The test was performed by extractive FTIR analysis on the inlet and outlet streams of the abator. The abator was operated with the bypass closed, so no airflow measurements were collected. Instead, the in and out airflows were assumed to be equal and the concentrations alone were used to calculate the destruction efficiency.

The abator destruction efficiency of the single successful run is given in Table 1. The first run was not successful due to sampling configuration and equipment issues. In the first column, only the data in which both the inlet and outlet results were above the LOQ were used in calculating the destruction efficiencies. This method of calculation is better suited for evaluating the performance of the abator on a continuing basis, such as for maintenance purposes, since the efficiency results will not depend on the timing of the samples or of the sterilization cycles feeding the abator. The second column shows the calculation for all the data collected in the run – the method typically used in performing destruction efficiency calculations.

Table 1 Average Results and Destruction Efficiency

	Run 2 when Outlet>LOQ	*Run 2 All Data*
Inlet (ppmV)	1500	650
Outlet(ppmV)	4.7	2.2
Efficiency	99.7%	99.7%

A plot of the ethylene oxide concentrations over time is provided in Figure 1 for reference.

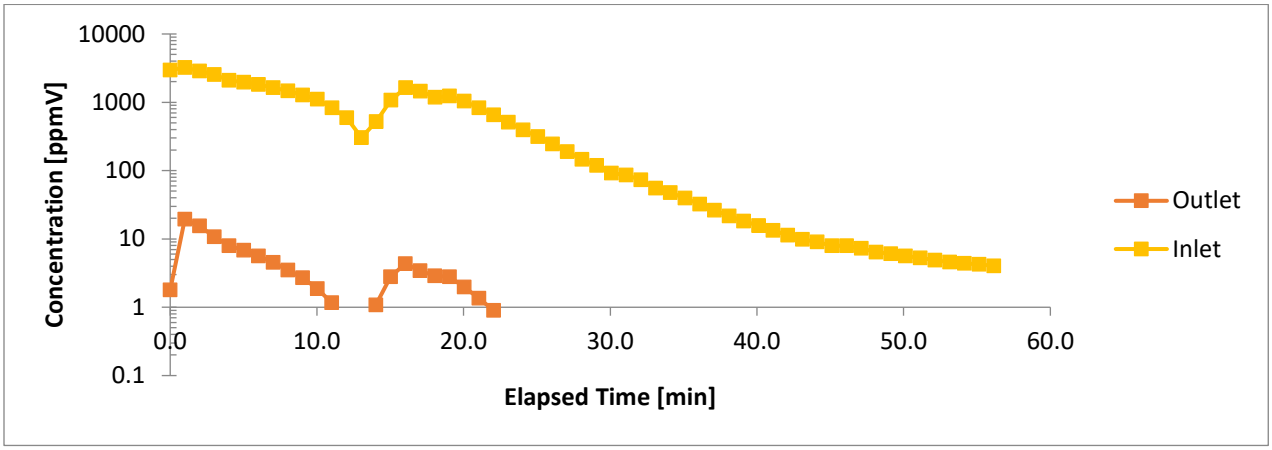

Figure 1 Abator I Ethylene Oxide Results over Time During Destruction Efficiency Test

2 Methods- Analytical and Preparatory

2.1 Method

Analysis was performed according to a procedure of ETS-8-31.4 “Measurement of Vapor Phase Compounds by Fourier Transform Infrared (FTIR) Spectrometry”, which is based on NIOSH 3800 and EPA Method 320.

The project quality level for this study was designated as “Level Two: Quantitative Monitoring”. Project Quality Level 2 (PQL 2) is appropriate for emission factor estimates and non-compliance test measurements. PQL 2 is appropriate when the project objectives specify the data will not be incorporated in compliance tests of manufacturing emissions, but can be used in certain environmental permitting and regulatory activities such as emission factor estimation.

2.1 Instrumentation

FTIRs with 5.11 meter nominal pathlength gas cell was used for the analysis. Table 2 gives sampling and configuration parameters of the instrument(s) used:

Table 2 Instrument Parameters

Instrument Name	1MKS	Tyrion
Model	MG2030	MG2030
Date Analyzed	11/12/2019	11/12/2019
Nominal Pathlength (m)	10.20	5.11
FTIR Cell Temperature (°C)	35	35
Number of Co-added Background Scans	128	128
Number of Co-added Sample Scans	64	64
Scan Range (cm-1)	650–4500	650-4500
Resolution (cm-1)	0.5	0.5

2.2 Calculations

2.2.1 AutoQuant/MG2000 Results

Results generated using the AutoQuant™ (v4.5) or MG2000 (v7.2) software are reported in ppmv (parts per million by volume). The software was used in conjunction with Midac, EPA, PNNL, MKS, and 3M library reference spectra, and manual subtraction of reference spectra in Thermo GRAMS/AI and/or MG2000.

These results are converted to µg using the following equation:

$$\mu g = \frac{Concentration\ (ppm_v) \times Sample\ Gas\ Volume(L) \times Pressure\ (atm) \times Molecular\ Weight\ \left(\frac{g}{mol}\right)}{0.08206(L \times atm \times K^{-1} \times mol^{-1}) \times Cell\ Temperature(K)}$$

Where Sample Gas Volume (L) = total chamber compressed house air purge gas volume during sample off-gassing or the volume of the gas cell.

2.2.2 Manual Subtraction

The concentration of a target analyte in a sample FTIR spectrum was verified using manual subtraction of a reference spectrum from the sample spectrum by means of Thermo GRAMS or MG2000 software. The relative fraction of the reference spectrum, or subtraction factor, is then used to calculate the concentration of the sample in ppmv using the following equation.

$$ppm_v = \frac{subtraction\ factor \times reference\ concentration\ at\ cell\ temp\ (ppm_v \cdot m)}{pathlength\ of\ cell\ (m)}$$

2.2.3 Limit of Quantitation

The limit of quantitation was estimated by manual addition of the analyte quantitative reference spectrum to the sample spectrum. Using the Thermo GRAMS or MG2000 software program, the reference spectrum was added until the analyte signal was approximately two times greater than the surrounding noise. The resulting addition (negative subtraction) factor was used to calculate a ppmv concentration using the equation listed in 2.2.2.

2.2.4 Destruction and Removal Efficiency Calculations

Destruction and removal efficiencies are calculated according to the following equation:

$$Destruction|Removal\ Efficiency = \frac{Inlet\ Mass\ Rate - Outlet\ Mass\ Rate}{Inlet\ Mass\ Rate}$$

In some circumstances, the inlet and outlet volumetric flowrates are assumed to be equal. The destruction or removal efficiency can be calculated by the following equation in those cases:

$$Destruction|Removal\ Efficiency = \frac{Inlet\ Concentration - Outlet\ Concentration}{Inlet\ Concentration}$$

3 Analysis

3.1 Calibration

The instrument was calibrated using a 19.8 ppmV certified (certificate archived with this report) standard of ethylene (cylinder # CC238177). The instrument gas cell pathlength was determined before and after sampling). The 1MKS pre calibration check was 15% low, but the final calibration check was within 1% of the cylinder value. This suggests that the signal was low initially but recovered by the end of the run. This may have been due to fogging of the optics under the cold operating conditions.

3.2 Blanks

Before and after each sample run, the sample-cell was checked for contaminants using compressed house air and/or house nitrogen or ambient air.

4 Data/Sample Retention

This report and all associated data will be archived and retained according to record retention policy.

5 Conclusion

Matrix spiking was not required for this project. Therefore, the uncertainty of the gas phase concentration of the given chemicals as measured using FTIR is +/- 25% and is based on 2 times the standard deviation of the most recent 51 recovery values measured in the ISO 17025 FTIR proficiency testing of 3M EHS Lab FTIR operators.
Results are only valid for the described test conditions and apply to each sample as received.

6 Signatures

Digitally signed by Kelly H. Sater
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